DTU Library

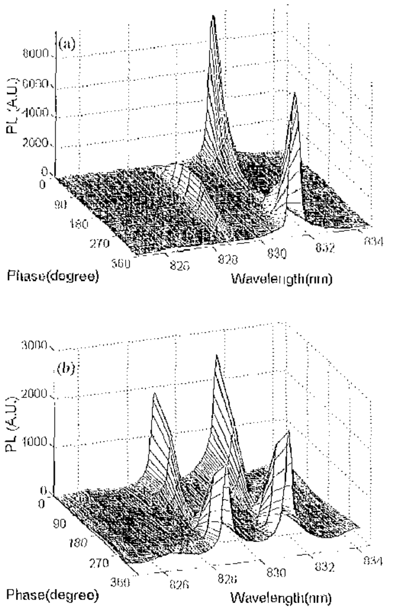
Seeding Dynamics of Nonlinear Polariton Emission from a Microcavity

Østergaard, John Erland; Langbein, Wolfgang Werner; Jensen, Jacob Riis; Hvam, Jørn Märcher

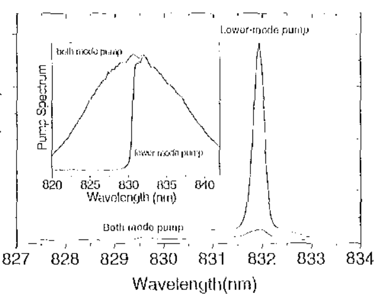
Published in:
Quantum Electronics and Laser Science Conference

Publication date:
2000

Document Version
Publisher's PDF, also known as Version of record



QThQ4 Fig. 2. PL spectra as a function of phase between two pump pulses when the temporal pump pulse separation (τ_{12}) is (a) 0.45 ps and (b) 0.90 ps. Pump fluence is 0.7 μJ/cm^2 pulse.



QThQ4 Fig. 3. PL spectra when both modes and only the lower mode are pumped. Inset shows the corresponding pump pulse spectra. Pump fluence is 0.7 μJ/cm^2 pulse.

trum which is a maximum or minimum at both modes simultaneously. Thus the modes can be independently controlled as expected for independent oscillators; however, the amplitude of the emission is not symmetric between the modes, indicating different excitation levels. This nontrivial difference in excitation is more dramatically shown in Figure 3, where we have plotted the PL spectra when only the lower mode is pumped and when both modes are pumped; lower-mode-only pumping gives rise to much stronger PL. These results will be discussed in terms of simple polariton models and a microscopic fully-quantized many-body theory.

*Department of Physics and Material Sciences Center, Philipps-University, Renthof5, D-35032 Marburg, Germany

**Optical Sciences Center, University of Arizona, Tucson, AZ 85721

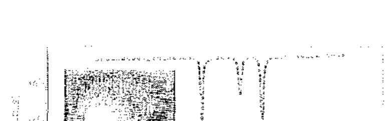
1. Y.-S. Lee, T.B. Norris, A. Maslov, D.S. Citrin, J. Prineas, G. Khitrova, and H.M. Gibbs, QMF1 in QELS'99.

QThQ5 **5:45 pm**

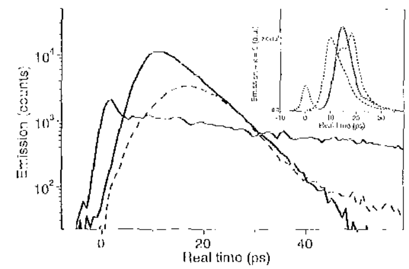
Seeding dynamics of nonlinear polariton emission from a microcavity

John Erland, Wolfgang Langbein, Jacob R. Jensen, Jørn M. Hvam, *Research Center COM, The Technical University of Denmark, DK-2800 Kgs. Lyngby; E-mail: jeo@com.dtu.dk*

The dynamics of polaritons in microcavity samples is presently under intense debate, in particular whether or not the so-called Boser action is possible.[1-3] In this work, we investigate a λ cavity with a homogeneously broadened 25 nm GaAs quantum well at the antinode at a temperature of 10 K. We can thus inject well-defined polariton populations in k-space revealing how different initial and final state populations may influence the dynamics. The reflection spectrum in Fig. 1 shows three polariton-modes of less than 200 μeV linewidth with the in-plane dispersion shown in the right inset. The modes result from the mixing of the light-hole and heavy-hole exciton with the cavity resonance (bare linewidth of 260 μeV, corresponding to a photon lifetime of 3 ps). For resonant excitation of the lower polariton (LP) branch at zero detuning with a shaped fs pump pulse and a parallel wavevector component $k_p = 5 \times 10^4$ cm^{-1}, a Rayleigh ring and an intense light emission centered at k_s between the excitation direction and normal direction is observed in the time-integrated far-field emission (Fig. 1, left inset). This emission I_s at k_s is spectrally narrow (~200 μeV, see spectra in Fig. 1) and shows a threshold-like behaviour for increasing excitation power (data not shown). Time-resolving I_s (Fig. 2) demonstrates that the scattering processes into the k_s states change character with increasing excitation intensity I_p. At low intensity ($I_p = 0.4$ mW), a rise time below 3 ps and an exponential decay of 120 ps is observed. Given the short polariton lifetime at k_s (<10 ps), this decay time is determined by the spontaneous polariton relaxation time from the k_p state to the k_s state. Increasing the I_p to 6 mW, a faster dynamical response appears with a risetime decreasing with increasing I_p, and a decay time of only 15 ps. Such a dynamics is typical for a stimulated emission process.



QThQ5 Fig. 1. Upper (lower) spectrum (dotted): white light (shaped laser) reflection at $k_p = 5 \times 10^4$ cm^{-1}. Right inset: measured in-plane dispersion. The investigated scattering from k_p states to the k_s—states is indicated. Left Inset: far-field emission image with the excitation mirror (right) and a block of the specular reflection (left). Emission spectra (full curves) at k_s for increasing power I_p up to 20 mW.



QThQ5 Fig. 2. Time-resolved traces of the nonlinear emission at k_s after injection at k_p: A decay time of 120 ps is observed for low intensity (0.4 mW) while much faster dynamics is seen for increasing intensities (3.5 mW (dashed) and 6 mW (full)). Inset: Time-resolved traces for seeded emission with a 4 mW pump at k_p and 20 μW seeding pulse incident at k_s seeding at 0 ps (dotted), seeding at 8 ps and 16 ps (dashed) and the unseeded emission for reference (full curve).

More evidence for a final-state stimulation of the scattering into the LP population at k_s is obtained by applying an additional weak seeding pulse at k_s. Our preliminary data suggest a super-linear dependence of I_s on the seeding intensity I_{seed} and show a dependence of I_s on the seeding pulse delay resembling the dynamics of the observed nonlinear emission. Time resolved traces, detected through a pinhole selecting $k_s = 0$ polaritons, are shown in the inset of Fig. 2. Compared to the unseeded emission peaked at 15 ps, the dynamics is changed when the seeding pulse appears around 15 ps. At a seeding delay of 8 ps, the maximum of the nonlinear emission appears earlier. For a seeding delay of 16 ps the emission amplitude at 15 ps is reduced (due to scattering to other k-states than those detected) and a delayed maximum appears as a result of further scattering into the k_s-states due to the seeding. The polariton population at k_s can thus *control* the polariton dynamics on the LP branch through what appears to be stimulated processes. A systematic study of the seeding dynamics of the nonlinear emission will be presented.

1. P. Snellart and J. Bloch, Phys. Rev. Lett. **82**, 1233 (1999).
2. Le Si Dang, *et al.*, Phys. Rev. Lett. **81**, 3920 (1998).
3. M. Kira, *et al.*, Phys. Rev. Lett. **79**, 5170 (1997).

QThQ6 **6:00 pm**

Nonlinear optics of polariton-polariton correlation in semiconductor microcavities

C. Ciuti, P. Schwendimann, B. Deveaud, A. Quattropani, *Physics Department, EPFL, CH-1015 Lausanne, Switzerland; E-mail: ciuti@dpmail.epfl.ch*

The strong coupling between quantum well exciton and cavity photon leads to the so-called microcavity polaritons whose energy dispersion is very sharp due to the photon component.[1] Unlike bare excitons, the optical response of polaritons is very sensitive to the

Thursday, May 11